

A SERIES
OF
EXPERIMENTS

PERFORMED FOR THE PURPOSE OF SHEWING THAT

ARTERIES

MAY BE

OBLITERATED WITHOUT LIGATURE,
COMPRESSION, OR THE KNIFE.

BY

BENJAMIN PHILLIPS.

LONDON:

PUBLISHED BY LONGMAN, REES, ORME, BROWN, AND
GREEN, PATERNOSTER-ROW.

1832.

R35692

TO THE RIGHT HONORABLE

HENRY,

BARON BROUGHAM AND VAUX,

LORD HIGH CHANCELLOR OF ENGLAND,

&c. &c. &c.

THE PROMOTER OF LEARNING,

THE POSSESSOR OF THE MOST VARIED ACQUIREMENTS,

THE CONTROLLER OF SENATES,

THE ADMIRATION OF HIS COUNTRY,

THIS ESSAY

IS (WITH PERMISSION) INSCRIBED

BY HIS LORDSHIP'S MOST OBEDIENT SERVANT,

THE AUTHOR.

*4, Welbeck Street, Cavendish Square,
January 1, 1832.*



TO THE PUBLIC.

THE experiments detailed in the following pages were performed in the hope of discovering some mode of arresting the progress and effecting the cure of aneurism without resorting to the use of the ligature.

To the non-medical reader, it may be necessary to explain, that an aneurism is a tumour, formed either by the dilatation of the parietes of an artery, or by the escape of a certain quantity of blood, which, in consequence of the solution of continuity of the arterial parietes, is infiltrated and forms a species of sac or cyst.

Aneurisms may exist wherever an artery is found.

They are diseases of a very grave and important character ; such gravity and importance being more or less influenced by the situation of the artery, its connection with other organs, and its proximity to the heart. They always create anxiety in the practitioner, and frequently prove fatal to the patient.

The progress of surgery may be advantageously contrasted with that of medicine ; and whilst, in medical science, we still receive as authorities the works of the fathers of medicine, few surgical productions of an ancient date retain the respect or esteem of the present professors of surgery.

The correct and extensive knowledge of anatomy now so generally diffused, and which we owe entirely to dissection, and the more perfect acquaintance we possess of the action in health and the changes from disease of the various

organs of the human frame, have tended to place the science and practice of surgery upon a rational basis.

Few diseases exhibit more marked evidence of the advance of surgical knowledge than aneurism ; few of the operations of surgery have tended more to the mitigation of physical suffering than those which have been from time to time adopted for the removal of this disease.

In the early history of surgery we find that science had presented humanity with no remedy for aneurisms. Patients were, at that time, always left to themselves ; and, unless nature herself furnished a remedy for the disease, death put an end alike to their sufferings and their lives.

For many ages scientific men have been occupied in endeavouring to lessen the ravages and arrest the progress of the disease.

The first remedy adopted for aneurisms was amputation : a remedy only available where the disease was situated at the extremities.

When amputation was first employed for the cure of aneurism I cannot determine; but it seems doubtful whether amputation had been performed for any purpose whatever, much before the time of Celsus, although allusion is made to the subject in the writings of Hippocrates; in a manner, however, so indistinct as to make us hesitate in asserting that the operation had ever been performed in his time.

When the ligature was first employed is not well known. Archigenes of Apamei, who lived at Rome in the reign of Trajan, first speaks of compressing arteries, in amputation, for the purpose of preventing hemorrhage; either by constricting the member according to Platner, or by the ligature according to Péryllhe.

The ligature is spoken of by Celsus in reference to hemorrhage:—"Venæ quæ sanguinem fundunt apprehendendæ, circaque id quod ictum est, duobus locis deligandæ, intercidentæque sunt, ut et in se ipsæ coeant, et nihil

“ominus ora præclusa habeant. Ubi ne id
 “quidem res patitur, possunt ferro candente
 “aduri.”

What may induce us to suppose that the mode of applying the ligature was unlike that employed in the present day, is, that Celsus, in speaking of amputation, speaks of it as excessively dangerous.

To amputation for aneurisms succeeded compression of the tumour, introduced by Guattani. In this operation the parietes of the artery were placed in contact, and the circulation of the blood in the arteries thus arrested.

To effect this object considerable and sustained pressure was required; and it was soon discovered that patients could not support the pressure for a sufficient time to remove the disease.

It was feasible only in aneurisms of the extremities, where alone we can produce the pressure necessary for accomplishing a cure.

Does compression possess any advantages not possessed by the ligature? The only one is, the absence of a bloody operation: but, far from being less painful, many persons have been unable to support it at all. It is more dangerous than the ligature. If it exposes him less to the apprehension of hemorrhage, it has more frequently produced gangrene of the extremity. It acts at the same moment upon the arteries, veins, lymphatics, and nerves. By this means it has destroyed the nervous influence, and prevented the reflux of the circulating fluids.

Compression was made upon the tumour alone, upon the entire extent of a member, between the tumour and the heart, or below the tumour.

This method was at the time much more successful than any other; and Guattani is said to have effected many cures. Until late times, the operation has retained some partisans; and it is useful when an aneurismal sac has been

opened by accident, or when, in consecutive hemorrhages, we find it impossible to apply fresh ligatures.

Cauterisation of an aneurismal sac with a red-hot iron was employed with success by Marcus Aurelianus Severinus in a large femoral aneurism.

No circumstances could be conceived to justify, in the present day, such a mode of proceeding, however fortunate may have been the result in this instance.

The facts mentioned by Paré, Trew, Guattani, and others, prove the dangerous nature of such applications.

About the same time was introduced the treatment of Valsalva, who debilitated the system locally and generally, for the purpose of weakening the circulation. This mode of treatment, which seems to have been attended with occasional success in dilatations of the cavities of the heart and the aorta, is not only inefficacious, but dangerous, in external aneurisms. Employed

in all its rigour, to which alone it owes its occasional success, it reduces the action of the heart insufficiently, the resisting power of the parietes of the diseased portion of the artery being weakened in a greater degree than the circulatory action of the heart is enfeebled.

When, accordingly, the debilitating treatment to which the patient has been subjected is superseded, and we gradually restore the circulation to a healthy activity, those parietes, possessing, as they did before, an insufficient resisting power, and partaking, as they have done, in the debility of the system, yield suddenly before the increased momentum given to the circulation, and the volume of the tumour is rapidly and alarmingly increased.

By this debilitating treatment the blood too acquires a serous character, increases in fluidity, and contains but a small proportion of coagulable lymph.

The rigid system of diet, the frequent vene-

section, the general depletion of the patient, render it nearly impossible that a concretion of coagulable lymph shall occur in the tumour; from which alone, by such treatment, we could reasonably hope to effect a cure.

These considerations establish the general inefficacy and the ordinary danger of the treatment of aneurisms introduced by Valsalva, and should serve to explode that treatment from our surgical practice.

The remedies for aneurism to which I have already directed attention, were succeeded by the ligature, which, with certain modifications, has been employed in the cure of aneurism from the time of Guillemeau to the present day. It is true the application of that agent has been modified, and that the operation has undergone various alterations and improvements.

If the operation has not, under every variety of circumstances, been attended with that success which may have been fairly anticipated, the

failure may be attributable, in some cases, to the progress the disease has been permitted to make before the ligature has been applied ; in others, to complications which may attend the operation. An impression has been entertained by the profession, that, when these tumours have attained considerable magnitude, their cure cannot be effected by the operation. There is too a physical impossibility, in the present state at least of our surgical knowledge, to obtain access to the artery in some situations where, by affixing a ligature, we might arrest the passage of the blood into the tumour.

It must also be admitted, that the application of the ligature is, in all cases, an operation of much delicacy to the practitioner, and of certain suffering to the patient, and that it is, in many cases, either inapplicable or unavailable.

Three principal modifications have occurred in the application of the ligature.

In the first of these modifications, the ope-

rator cut down upon the sac, and tied the artery on both sides of the tumour. This was a method employed by Guattani.

In the second, the operator avoided the tumour, placing the ligature upon the artery in a situation more or less distant from the aneurism, and between the tumour and the heart.

Of the many inestimable benefits conferred on science by our illustrious countryman, John Hunter, few have been more valuable in their effects, and none have mitigated in a greater degree the sufferings of humanity, or oftener prolonged human life, than this operation for aneurism, which was introduced by him in the year 1785, was soon universally adopted, and is still generally employed.

The remaining modification of the operation by ligature was recommended by Brasdor, and is performed by applying a ligature beyond the tumour ; the value of that operation depending on its applicability in cases where the situa-

tion of the tumour makes it physically impossible to apply the ligature between the tumour and the heart.

The serious inconveniences attendant upon the first operation have consigned it to entire oblivion.

The necessity of opening a cavity, often of considerable size, the irritation as well as the frequently profound alteration in the texture of the parts through which we cut, the inflammation and the occasional profuse suppuration that have followed the operation, have, in very many instances, occasioned the death of the patient.

It is often difficult to discover the portion of the artery in immediate communication with the tumour ; and the organs in relation to the artery frequently exhibit considerable displacement.

We may thus apply the ligature around veins, nerves, or other organs, as well as the artery, and by this means occasion serious complications.

The ligature is also applied to a portion of artery most frequently in a diseased condition.

The ligature is then thrown off before adhesion and obliteration take place ; and consecutive hemorrhage succeeds, which may be fatal to the patient. These were the principal reasons for abandoning this operation and adopting the improved mode of applying the ligature recommended by Hunter.

Doubt appears to exist whether the operation of Brasdor has ever been successfully performed.

Deschamps, who seems to have been the first individual that ever performed the operation, found it succeeded by a rapid increase and rupture of the tumour.

Sir Astley Cooper, who next performed the operation, states that, during the first days, the ligature came away without hemorrhage ; and he then felt confident of its success.

The rupture of the sac, however, took place, and the patient died.

Mr. Wardrop has published some observations upon the operation. In three or four cases he

has performed the operation ; and, in one instance, he believes with success.

The want of success which has attended this operation must be attributable to the existence of an important branch of the artery at a point between the situation of the ligature and the aneurismal tumour.

Coagulation could not then be produced : the circulation would continue in the diseased portion of the artery ; obliteration would not have place ; and the increased pressure produced in the tumour by the ligature might hasten the rupture of the aneurismal sac.

If the reason I have assigned for the want of success in this operation be the correct one, it is evident there are but few situations in which the operation can be available.

The carotid arteries perhaps alone in their structure and extent, present us with the means of affixing a ligature in such a situation, that no branch of the artery shall exist between the ligature and the tumour.

The existence of the epigastric artery near the situation that we propose to apply the ligature would render the operation unavailable in the thigh; for, if the epigastric artery is given off above the ligature, the permeability of the sac will be preserved; if given off immediately below, the blood will be propelled against the ligature; and, if adhesion of the parietes should not have taken place, consecutive hemorrhage will succeed the escape of the ligature.

It must be, then, obvious that this operation is available only in a very limited number of instances.

Although the operation perfected by Hunter in the eighteenth century appears to have been performed in the sixteenth century by Guillemeau, in which case he opened the sac, and in the seventeenth by Keisler and Anel, who did not open the sac, those men seem to have adopted it from necessity, in consequence of being unable to apply the ligature directly to the tumour, and were

not sensible that the mode in which they so performed the operation was a decided improvement upon the existing practice. Indeed, we find that Molinelli speaks of its performance with much reprehension; so that it was neglected until 1785, when it was performed by Desault and Hunter, the friends of each claiming priority.

The operation for aneurism according to the method of Hunter is immediately followed by these results: the course of the blood is arrested before it reaches the tumour; the tumour is separated from the circulation; coagulation of the blood contained in the artery generally takes place, and is succeeded by adhesion to the parietes, by which means the obliteration of the artery is completed.

It seems, therefore (with the slight exceptions I have noticed in treating of the operation recommended by Brasdor), to embrace every advantage we can derive from the application of the ligature.

But it must be recollected, that, in performing even this operation, difficulties of considerable magnitude are presented, and accidents of a serious character developed.

In certain situations, such as the subclavian artery in some portions of its course, the greatest difficulty is found, even when the artery is laid bare, to place a ligature around it.

In many instances, veins or branches of nerves are included in the ligature, occasioning in the one case phlebitis, and in the other extreme pain.

The injury consequent upon the operation, and the necessary exposure of the organs, frequently produce inflammation, which is succeeded by suppuration, and occasionally by fatal complications.

From a diseased state of the artery itself, which frequently occurs, coagulation does not take place; the artery remains pervious; the ligature ulcerates the coats; and, when it is thrown off, hemorrhage succeeds.

What is it which, even in the present day, and in our present mode of operating, renders so doubtful the success of the operation for aneurism?

How is it so many patients are lost? Almost entirely in consequence of consecutive hemorrhage.

The artery is ulcerated at the situation where the ligature has been applied; a new ligature is placed nearer to the heart; another rupture or ulceration takes place; a fresh hemorrhage succeeds; and the patient, at last exhausted, loses his life with his blood.

It is true all those persons who die in consequence of the operation for aneurism do not die from hemorrhage; but, under ordinary circumstances, patients are much exposed to this fearful accident.

Very extended opportunities of observing the progress and the effects of aneurism, the occasional difficulties of the operation by ligature, the not unfrequently serious and sometimes fatal consequences which have attended the operation, in-

duced me to ponder long and anxiously on the possible means of lessening the difficulties and avoiding the dangers of that operation.

The conviction had been long entertained by me, that, if I could devise any mode by which inflammation might be excited in the parietes of an artery, that inflammation would be succeeded by coagulation, and a consequent obliteration of the artery.

Although this conviction continued firm and unshaken, I saw no mode by which I could excite that inflammation, without resorting to the use of the knife, and laying bare the artery; and, unless the necessity for this operation could be avoided, the production of such an inflammation would perhaps possess no advantage over the application of the ligature.

The following pages will explain the circumstances which, occurring from time to time, tended to strengthen the impression I entertained. They will also exhibit the mode I adopted for

testing the correctness of my opinion by actual experiment, and the complete and entire success of the experiments I have made.

If those experiments, and the very important conclusions which they establish, should prove available for the prolongation of human life, or even the mitigation of human suffering, my fondest hopes will be fully realised, my greatest anxieties amply rewarded.

In the summer of 1830 I witnessed, in Paris, the success of an operation, which had been invented by Amussat, and which he was then perfecting, having for its object the obliteration of arteries upon amputated surfaces, without the aid of compression or the ligature ; an operation performed by twisting the artery upon itself, and which M. Amussat termed “ torsion.”

I became at that time more strongly than ever impressed with the notion, that some method

might be discovered for superseding, under almost every circumstance, the ligature and compression, as means for the obliteration of arteries.

Although this notion constantly presented itself to my mind, I saw no definite mode of effecting what I had in view, until the early part of the year 1831; when a series of circumstances, which I shall presently detail, presented themselves to my consideration; and, having satisfied myself of their accuracy, I proceeded to build upon them a theory which is the subject of the present Essay. I now resorted to a series of experiments, which were commenced in the month of March last, and which have served, as I submit, to justify the opinion I had formed, and to confirm the correctness of the theory I had constructed.

Tunics of arteries are rarely affected with inflammation; and, possessing just that degree of vitality necessary for the reparation of the losses to which, in common with all living solids, they are subject, we may almost regard them as rang-

ing themselves upon the same line with aponeuroses, tendons, &c. Thus we see them, in tuberculous, carcinomatous, or phlegmonous cavities, invulnerable to the attacks of the disease which is devastating all the other tissues; and even acute or hospital gangrene frequently respects arterial tissues.

This singular circumstance appears to be scarcely explicable, when we consider that the external coat possesses a cellular character.

The difficulty of furnishing such an explanation is, however, removed, when we reflect that cellular tissue is accessible to inflammation in an inverse ratio to its density, proceeding step by step from the least dense, as that of the eyelids, to the firmest, as the cellular tunic of arteries, aponeuroses, tendons, &c. From this it follows that the cellular coat of arteries is very rarely inflamed, either primitively or consecutively, and that inflammation occurring in arteries is generally an idiopathic disease.

The nature of the internal coat has occasioned much discussion. It has been compared by some to the epidermis, and by others to an inorganic product of secretion ; but the question here is, not what is its nature, but is it susceptible of inflammation ? It is certain, that, if blood no longer circulates in an artery, it becomes obliterated ; examples of which are presented to us in the ductus arteriosus and the umbilical arteries, and also in portions of arteries obliterated by ligature. That the obliteration of the umbilical arteries is a consequence of inflammation, is rendered evident by the observations lately made, which shew that pus is occasionally found in these vessels.

We very commonly find in the arteries, after death, a redness, which was first particularly noticed by Frank, but which is most frequently a post-mortem alteration. The inflammatory redness is less uniform in its character, and very rare in its appearance.

There can, then, be little apprehension of exciting too much inflammation in the internal or other coats of an artery.

I shall now submit the data upon which I found the opinion, that arteries may be obliterated without compression or the ligature, by exciting in the coats of an artery a sufficient inflammation.

In aneurisms formed by simple dilatation, no alteration of texture is presented by the arterial parietes in their vicinity; and yet fibrinous matter is occasionally deposited there.

If we moderately compress the parietes of an artery, so as wholly or nearly to efface the cavity, without rupturing either of its tunics, we find, at the expiration of twelve or fifteen hours after the operation, in the interior of the canal, at the compressed portion, a thin coagulum, partially colourless, united to the internal tunic by a very thin lamina of reddish mucosity; the internal tunic, reddish, a little softer than in the state of

health, but not thickened, and its adhesion to the middle tunic undiminished. (Gendrin.)

In thirty to forty hours after the commencement of the operation, the internal tunic, still a little coloured, corresponds, in the compressed portion, to a fibrinous stratum interposed between the parietes; and strongly adherent to the parietes, and to the corresponding fibrinous stratum, is a very viscid reddish fluid.

In the fourth or fifth day, all the tunics are confounded at the compressed portion. (Gendrin.)

If we inject an irritating fluid into a portion of an artery compressed between two ligatures, and previously emptied of blood, an inflammation succeeds which is characterised by a very obscure redness of the membrane, and by the formation of a plastic coat which lines the internal tunic, and which becomes a body that fills the canal.

We find, after death, coagulated blood either in the heart itself or the larger vessels leading to it; and such coagulum, even in the absence of

inflammation, is frequently in intimate adherencé with each of these organs, by means of vascular connection ; an adhesion which is dependent upon that general law, that two living parts cannot be long retained in contact without becoming united.

An organization of the coagulum also takes place in obedience to another law, which is, that blood, being placed in a state of stagnation in the living body, has a tendency to become organized. (Andral.)

This law is confirmed by Bouillaud, who found the right auricle nearly filled by a soft coagulum, traversed by an infinity of vessels, injected by a fluid of a vermillion or blackish red colour ; and his Memoir on the Obliteration of Veins contains other examples equally conclusive. A case is also mentioned in the Bulletin des Sciences Medicales, for September 1828, by Rigacci, in which similar vessels seen with a powerful glass appeared to be filled with a reddish fluid. They were injected with mercury ; one

was ruptured, the other was entirely filled, and was seen dividing into a number of ramusculi.

The method of curing aneurisms employed by Valsalva succeeded, by producing in the blood, in succession, stagnation and coagulation, followed by obliteration of the tube.

The operation proposed by Scarpa for the purpose of obliterating arteries communicating with aneurismal sacs was often successful. It was performed by placing a broad tape around an artery, by which the parietes of that artery were brought into contact, occasionally without being attended with ulceration.

If we take into consideration the circumstances attendant upon the application of ordinary ligatures, which are applied with the hope of exciting inflammation of the internal coat, without which it has been held that obliteration would not be effected, we cannot fail to observe, that, as an aphorism, it is stated, that we must not place a ligature around an artery in a situation very

near to the spot where a branch is given off, or coagulation will not occur, and the operation will be unsuccessful.

Considering the last position, it becomes evident, that it was not alone by inflammation of the internal coat of the artery, but by the organization of coagulated blood, which became attached to the sides of the artery, that obliteration was produced.

In obliteration by the ligature, where the inflammation consequent upon the destruction of the continuity of the internal and middle coats is often restricted to the immediate vicinity of the ligature, the artery, through the intermedium of a coagulum, is frequently obliterated for an inch or more.

Well-authenticated cases are presented where, in consequence of the existence of chronic inflammation in the mitral, semilunar, and venous valves, terminating by the development of cartilaginous or fibrous tissue, a coagulation of the

circulating blood has taken place upon these organs, which blood has become either organized or attached to the valves, in a similar manner to false membrane.

Dupuytren has found the femoral and popliteal arteries completely obliterated, and converted into a fibrous cord, in a person who had pointed exostoses upon the femur, which had perforated the artery.

It is asserted by a man whose knowledge of pathological anatomy is as extensive as that of any individual of the present day (I mean Dr. Carswell), that a coagulation or deposition of fibrine will not unfrequently take place upon those spiculæ of osseous matter which are developed and project into the interior of an artery, and obliteration of the artery be thus produced.

Wounds made in an artery either by puncture or cutting are never cicatrized without the obliteration of the artery, and its conversion, for a greater or less extent, into a ligamentous cord.

All causes which will arrest the course of the blood, or which will inflame the arterial parietes, and apply them the one against the other, will procure the obliteration of arteries.

If the course of the blood be materially arrested, and the arterial parietes applied the one against the other, an inflammation will be determined in the internal membrane, which will produce the mutual adhesion of the opposed parietes.

Satisfied of the correctness of the foregoing data, I conceived I was justified in coming to the conclusion, that an artery may be obliterated,

First, by the existence of inflammation within its coats, producing adhesion :

Sècondly, by lessening the force of the circulating fluid, without the existence of inflammation, by the formation of a clot :

Thirdly, by the intermedium of both these causes in concert :

Fourthly, that the existence of a foreign body

in the canal, in the absence of other diseases, will arrest the progress of the circulating fluid and favour the production of a coagulum: and,

Fifthly, by the introduction of a foreign body into the canal, creating or accompanied by inflammation.

To establish the correctness of the latter positions, I engaged in the series of experiments I am now about to detail.

The animals upon which I operated were, with only two exceptions, dogs; the arteries upon which I experimented, the femorals and the carotids, which were selected simply from the greater facility with which they may be transfixed.

FIRST EXPERIMENT.

Three needles were introduced in the situation of each of the carotid arteries of a dog, and were then pressed upon until they were supposed to have transfixed the artery.

At the same time, the two femoral arteries were subjected to a similar operation; two needles only being used for each instead of three. The dog was then set at liberty in a room.

During the following day he appeared to be suffering pain, but took his food; and on the third day he seemed perfectly cheerful and free from pain.

The needles were removed at the end of twenty-four hours from the right carotid—of forty-nine hours, from the right femoral—of seventy-one hours, from the left carotid—and of ninety-nine hours, from the left femoral.

On the eighth day from the performance of the operation the dog was destroyed, by means of prussic acid. On the following morning I proceeded to examine the arteries in the order in which the needles had been removed.

On laying bare the right carotid, I was not able distinctly to trace the situation which had been occupied by the needles; nor, upon slitting

up the artery, was I enabled to determine whether or not it had been transfixed.

There was no redness nor inflammation perceptible; and, though I was much inclined to think that the artery had been perforated, there was not the slightest trace of the formation of coagulum.

The right femoral had not been transfixed; there were some slight arborescences in the cellular tissue in the vicinity of the artery; but the arterial tunics were not implicated.

The left carotid had been perforated, and one of the needles was found to have occupied the parietes of the œsophagus, but had excited in that organ only a slight redness.

The needle which had perforated the artery had transfixed it, and the point had lodged in the pneumogastric nerve, but had occasioned in the colour or consistency of the nerve but little change, and in its function none.

The artery, when slit up, presented a firm co-

agulum, of about nine lines in length, adhering tenaciously to the arterial parietes, which, after the removal of the coagulum, presented a vivid red colour, the cellular tunic being strongly injected.

The left femoral artery was not perforated, and, although the cellular tissue near it was much injected, the redness was not extended to any portion of the artery.

SECOND EXPERIMENT.

The same arteries were subjected to the operation as in the last experiment.

I here again made the application at the same time to each of the carotids and femorals; the needles were removed in the same order as in the last experiment, from the right carotid at the termination of twenty-four hours, the right femoral at the end of forty-eight hours, the left carotid at the termination of seventy-three hours, and one of the needles from the left femoral at the

end of ninety-six hours; but the other, in consequence of the uneasiness of the animal, had found its way under the aponeurosis, and I was obliged to allow it to remain there until the animal was destroyed. On the ninth day after the introduction of the needles, the animal was destroyed by the same means as in the former case. On the tenth day, I made an examination of the arteries, and, on examining the carotids, found that I had not succeeded in perforating or indeed implicating any nerve or vessel; but there was a slight extravasation of blood in the substance of one of the recti capiti antici muscles of the left side.

The femoral of the right side I found had been transfixed, and the hole from which I had removed the needle was distinctly visible. On slitting up the artery, I found a coagulum of the usual form, an inch in length, adhering firmly to the sides of the canal, which, after removing the clot, I found red, and covered by

a thin stratum of a viscid lymph-like matter, extending a little beyond the clot. I here observed, that, on the peripheral side of the clot, this stratum of lymph appeared to extend to the distance of nearly a line beyond the clot.

The several tunics forming the arterial parietes were not demonstrable, and, when cut through, appeared to possess a uniform structure.

On the left side I found, in the neighbourhood of the artery, considerable inflammation, which was also, though in a much inferior degree, perceptible upon the cellular coat of the artery, but was not propagated to the middle coat. The artery had not been perforated; but one of the needles had transfixed the femoral vein, the tunics of which were much inflamed, as far as the common iliac; and in this canal was found a large mass of coagulum, not adherent, but separated from the internal tunic by a semifluid substance of a puriform character.

THIRD EXPERIMENT.

In this experiment, I introduced, in the situation corresponding to each artery, two needles, which I permitted to remain thirty-six hours, when they were carefully removed ; and on the eighth day I destroyed the animal with prussic acid.

In twenty-two hours after death, I proceeded to examine the arteries, and found that I had transfixed two carotids and one femoral ; and, although in each case there was a redness very perceptible on the external coat, and I thought slightly on the internal, yet there was no coagulum formed. I found, however, in one of the carotids, at a short distance from the redness, a small mass of coagulum ; and, although this might be a post-mortem production, yet it certainly may have been produced by the operation ; an opinion which was strengthened by the circumstance, that, in consequence of the prussic acid being weak, the animal struggled much in dying, and may have detached a recently formed coagulum.

Being dissatisfied with this experiment, and being anxious to determine whether obliteration may be effected if the needles be removed so early as the expiration of thirty-six hours after the operation, I performed another experiment under similar circumstances.

FOURTH EXPERIMENT.

In this case, I introduced, as in the last, two needles in the situation of each of the arteries, which were allowed to remain thirty-six hours ; at the expiration of which period they were removed ; and on the seventh day I destroyed the dog.

In twenty-four hours after death, I examined the arteries, and found the right carotid and left femoral perforated by the needles. The other needles had not implicated any important organ, being at a distance, from the left carotid, of five or six lines, and the right femoral of three or four lines. In the right carotid, which had been

perforated by both needles, I found a considerable redness on the external and internal coats, with a very trifling exudation of lymph upon the latter, but no appearance of coagulum.

Upon the needles, when removed, there was a very small quantity of a lightish-coloured substance, apparently fibrine. The needles were three lines removed from each other, appearing to have passed in contrary directions, forming an X, and must have tended materially to impede, at this point, the circulation of the blood. In the left femoral, which was transfixed by one needle, I could not discover any positive evidence of inflammation, either in the external or internal tunics; nor was there any appearance indicating the formation of a coagulum; yet there was a diffused redness visible on the internal coat.

FIFTH EXPERIMENT.

In this instance, two needles were introduced in the situation of each carotid and each femoral

artery. They were suffered to remain there forty-eight hours; at which period they were removed; and the dog was destroyed on the tenth day.

In twenty-four hours after death, the animal was examined; and the right carotid was found perforated by two needles, which were situated at a distance of two lines from each other: the left carotid was not perforated; but one of the needles had occupied the parietes of the œsophagus, which presented a very slight redness.

The right femoral, as well as the left, was perforated by one needle, the other needles being removed to a short distance from the arteries.

The right carotid, when slit up, presented a clot which occupied a space of eight lines, not extending to the first branch, which was given off. This coagulum adhered with much pertinacity to the arterial tunic; and, in removing it, I saw, or fancied I saw, by the assistance of a glass, two communicating vessels: but of this I was not well assured.

The internal tunic presented a rather uniform redness, and could not be detached from the middle tunic.

The right femoral presented a coagulum, of the length of seven lines, not very firmly adherent to the arterial tunics, but moveable. In consequence of an accident, I did not examine the state of the internal tunic.

In the left femoral, I did not find any coagulum occupying the centre of the artery; but there was a stratum of coagulable lymph, about a line in thickness, and four lines in length, attached to the anterior parietes of the artery, but not extending to the circumference. The needle had not transfixed this artery, having only perforated the anterior parietes.

SIXTH EXPERIMENT.

As in the other cases, two needles were introduced in the situation corresponding with each artery.

In seventy-two hours after their introduction, they were carefully removed ; and, at the end of seven days, the animal was destroyed by means of prussic acid. In sixteen hours after its death, I commenced an examination of the arteries which had been subjected to experiment. In this instance, both carotids were perforated ; the right by two needles, the left by one only.

Of the femorals, one only was transfixed, and that by a single needle.

In the right carotid, a clot was formed, of the length of five lines and a half, terminating three lines and a half before the giving off of the next branch, and presenting the same character with that produced by the last experiment.

In the left carotid, the needle had transfixed the artery, and pierced the pneumogastric nerve, the neurilema of which appeared slightly injected ; but no derangement was manifested in any of the organs which it is destined to supply with nervous matter.

On slitting the artery, I found a clot, fourteen lines long, not adherent to the arterial parietes, which were scarcely at all red. The clot was evidently produced by the coagulation of blood upon the needle, which appeared to have formed the nucleus of the clot.

This circumstance occasioned me some surprise; but I conclude, that, had the coagulum been longer in contact with the arterial parietes, a sufficient inflammation would have been excited in those parietes to procure the adhesion of the clot thereto, and the consequent obliteration of the artery; an opinion which the next experiment I made appeared to justify.

In the right femoral, although only one needle had perforated the artery, so much irritation had been occasioned in the surrounding cellular tissue, that the artery, vein, and nerve were all firmly adherent. The vein contained no indication of inflammation in its interior; but the external tunic appeared thickened.

The artery was filled by a clot which extended to a distance of five lines on one side of the needle and three on the other, and firmly adhered to the arterial parietes.

SEVENTH EXPERIMENT.

The needles were introduced in the same situations as before ; and in ninety-six hours after their introduction the animal was destroyed.

This dog was a rough terrier, exceedingly irritable, and constantly occupied in endeavouring to remove the needles. In twenty hours after death I examined the arteries, and found that I had succeeded in transfixing both femorals, but failed to perforate either of the carotids. Indeed, from his violent struggles, I feared that I should not have succeeded in perforating a single artery.

I found the single needle which occupied the right femoral perfectly moveable, and surrounded by pus. This had been occasioned by

the irritability of the animal, which constantly rubbed the needles.

On arriving at the vessel, I found the perforation in which the needle was situated sufficiently large to have admitted three needles of a similar size to those I used.

A considerable coagulum existed (in the centre of which the needle was placed). I carefully removed the needle, made a longitudinal incision in the clot, and discovered a cavity of near a line in diameter, so that the clot appeared to be breaking down by a formation of pus; the coagulum was firmly attached to the sides of the artery, and a transverse incision, made through the clot and tunics of the artery, shewed an almost perfect continuity.

The femoral artery of the left side was transfixed by a single needle, and obliterated, as in former instances, without the existence of any suppuration.

EIGHTH EXPERIMENT.

In this instance I allowed the needles to remain in the arteries during one hundred and twenty hours ; at which period I destroyed the animal.

In twenty-two hours afterward, I proceeded to examine the arteries, and found that the two femorals and the right carotid had become the seat of profuse suppuration ; simply, as I conjecture, from the uneasiness of the animal, and his constant efforts to rid himself of the needles. There was, however, only one artery transfixed, the right carotid, where I found a clot from four to six lines in length : the inflammation had procured adhesion of the parietes of the artery to those of the jugular vein, and to the coverings of the pneumogastric nerve ; but neither of the latter, however, was otherwise affected, the vein being still perfectly pervious, and the function of the nerve apparently not deranged.

The artery which was transfixed presented an important circumstance : a large ulceration, corresponding to the situation of the needle, by which one half of the circumference of the artery was destroyed ; and I have no doubt, if two or three days more had elapsed before the destruction of the dog, the entire of the circumference would have been destroyed ; and its state would then have been precisely similar to that of an artery when the ligature comes away.

On either side of this ulceration, adhesive inflammation was produced, as if for the purpose of retaining the pus within narrow limits ; and beyond this inflammation, above and below, the artery presented an entire obliteration.

NINTH EXPERIMENT.

As in the previous experiments, two needles were introduced in the situation corresponding to each of the femoral and carotid arteries.

In sixty-two hours after their introduction, the animal was destroyed.

On examination after death, I found that each of the carotid arteries had been transfixed by one needle; the left femoral I found perforated by two needles, one of which passed through the centre of the canal, the other merely passing through the parietes; the right femoral I had not succeeded in perforating.

The carotids were each occupied by a coagulum; the one of the length of eleven lines, the other of fourteen lines: they were each adherent to the parietes, which were much injected and slightly thickened.

The femoral presented a more intense inflammation than I had yet seen; but it was principally limited to the external or cellular tunic. The coagulum which I found in its interior was fifteen lines in length, and strongly adhering to the internal tunic, which presented a vivid and extended redness.

In this case the inflammation which was manifested was more considerable than in any other experiment; yet, in this case, it did not

appear to have been sufficient to interfere much with the health of the animal.

TENTH EXPERIMENT.

In this experiment, the dog was so powerful, and his struggles so violent, that, after having introduced a single needle in the situation of the femoral artery, I was obliged to desist from attempting to introduce any more.

Circumstances prevented my destroying him, or indeed removing the needle, until the expiration of eighteen days, when it was found that the artery was not perforated ; but the needle was seen to occupy the crural nerve. Although it had been imbedded in this organ during so long a time, it had produced only a slight thickening of the nerve, and a very trifling degree of lameness.

I have made some few experiments besides those which I have detailed ; but as they were

less conclusive, I have not thought it necessary to introduce them here.

In principle, they did not differ from those which are contained in the preceding pages.

Two experiments were made upon horses ; but, immediately after the introduction of the needles, I was obliged to leave town ; so that I had no opportunity of making a post-mortem examination.

I learned that, in cutting the throat of one of the animals, no blood appeared to flow from one of the carotids ; but whether it had been perforated by the needles I am not able to state.

From the results of the foregoing experiments, I am justified in deducing the following conclusions :

I. That acute inflammation is not easily excited in the tunics of arteries, even by the introduction of a foreign body.

II. That obliteration of an artery may take place, by the formation of a clot, without being

preceded by inflammation of the internal tunic.

III. That when a clot is formed, and in apposition with the internal tunic of an artery, an adhesive inflammation is commenced ; a vascular connection succeeds ; the clot becomes organized ; and the obliteration of the artery is completed.

IV. That the introduction of a foreign body into an artery may occasion the formation of a clot or coagulum, from the blood circulating in that artery.

V. That arteries may be obliterated with safety and certainty by the introduction into them of a foreign body.

VI. That, from the facility of introducing a common cylindrical needle, and the little irritation occasioned by its presence, such a body should have the preference.

VII. That, as the object is as much to interrupt the course of the circulating fluid as to excite

a primary inflammation, two or more needles should be introduced.

VIII. That in the carotid and femoral arteries of dogs, if the needle be removed before the expiration of forty-eight hours, we shall not succeed in obliterating the artery, and that it is more prudent that they should remain sixty hours.

IX. That the presence of needles in four arteries, at the same moment, occasions a very trifling degree of general irritation.

X. That perfect rest should be observed, at least during the presence of the needles in the arteries, or they may occasion suppuration.

XI. That an artery is not generally obliterated beyond the clot, and that the clot does not necessarily extend as far as the situation whence the first branch is given off.

XII. That care should be taken to remove the needles whenever any tendency to suppuration is manifested; and, if obliteration be not effected, they may be again introduced.

In conclusion, I trust I shall be allowed a few words, for the purpose of entering into an explanation, which can scarcely have more than a personal interest, but which, in justice to myself, I am compelled to make.

At the time I had completed the preceding experiments, and drawn up the greater part of the present paper, I communicated to Dr. Carswell the experiments and their results.

My surprise may be imagined when he informed me, that three or four similar experiments had been made by Velpeau, in Paris, and that they had been repeated in two or three instances by Amussat and himself; that large pins had been used; that excessive inflammation was produced; and that, although in one or two cases coagula had been formed, yet the experiments had been deemed inconclusive. This impression was confirmed by Majendie, who was in London a few days since.

In addition, I was informed that the fact had

been mentioned in the *Journal Hebdomadaire de Medicine* ; and, on since referring to a volume of that work (which I am informed by the publisher of that work arrived in London in March), I have found that an article on that subject is there introduced; but the experiments, being inconclusive, are not detailed.

I am thus obliged to state, that I have never read, except in this instance, a number of that work, and that I had not the slightest reason to suppose that the view I have taken of the subject had occurred to a human being, until the communication to which I have referred was made to me by Dr. Carswell.

I am in a condition to prove, most satisfactorily, that my experiments were commenced in the beginning of March, and that I had completed five experiments before May.

Having left town in May, and being at the Bristol Infirmary, I communicated, in confidence, to my friend Mr. Daniel, one of the sur-

geons of that infirmary, the nature of the experiments and their results, and expressed a wish that he would repeat them on any suitable patient; a proposal to which he demurred, until I should mature my experiments.

At the same period I communicated the subject to two or three other persons, each of them ready to bear testimony to the truth of this statement.

I am, then, in a condition to prove, that, although M. Velpeau may have performed experiments of a similar character to mine, previous to those which I have performed, yet that I have first satisfactorily established the principle; that I have performed the preceding experiments entirely independent of him; and that mine are the only connected series of experiments which has been given to the world.

APPENDIX.

IN the course of the experiments which have been detailed in the preceding pages, I became strongly impressed with the belief, that arteries might be obliterated by galvanic action ; and I therefore determined on testing the correctness of this opinion.

The experiments now about to be detailed were accordingly performed by me, and the results answered my most sanguine expectations.

Deeply impressed with the great importance of the discovery, I lose no time in publishing it to the world, and earnestly invite the attention of all men of science to the results of the experi-

ments and to the considerations to which they naturally give birth.

When electricity was first applied to the human body, all were surprised by the energetic action which it exercised; and the observation of these phenomena, and the remarkable facility and regularity with which these phenomena may be produced, gave birth to brilliant hopes and seducing theories: it was believed we had discovered and seized the principle of life, and that, by its agency, we might reanimate the dead. How little, however, remains, in the present day, of this fancied power!

Much difference exists in the results obtained by the action of electricity administered by means of the galvanic pile and those which are produced by the use of the machine: the action of the first is more sustained, that of the second is more energetic.

If we apply a pointed conductor to the skin, and if the sparks are numerous and rapid, the

skin becomes painful and red, and is soon the seat of inflammation: this inflammation may be so intense as to be succeeded by mortification.

The circumstances attendant upon the application of electricity by means of a galvanic pile, although analogous to those just mentioned, yet offer some peculiarities which we must not neglect.

If we apply upon the skin, previously moistened, the zinc conductor of a galvanic pile, the copper pole being applied at a short distance, a painful sensation of heat and pricking is experienced, and the part in immediate contact with the conductor becomes the seat of inflammation, which, if the power of the pile be great, advances rapidly to gangrene.

When we direct the action of galvanism upon an exhalant surface, either natural or accidental, for example, a wound, it immediately becomes covered with a puriform fluid.

In galvanism, we have a method of adminis-

tering electricity conveniently and energetically, and much less influenced by atmospherical vicissitudes than the machine.

It is necessary to ascertain the power of the shocks before they are applied to the patient; and we shall generally find, that a small number of pairs of plates are sufficient to produce very sensible effects.

We must not forget that humidity is indispensable to the development of the effects we require, and that, in consequence, the parts upon which we apply the conductors, must be moistened with pure or acidulated water.

While almost every other medical agent introduced into the economy may produce effects not easily calculated or foreseen, and which it is impossible to limit when they take an exaggerated character, the stimulus produced by electricity may be directed upon a single point, sustained or increased at will, and, if necessary, suspended in a moment.

By its agency we may excite at will any part, without the participation of any other, or, what appears more extraordinary, stimulate the entire of the organization, with the exception of a diseased or delicate part.

Such are the effects of this powerful agent when applied to the living body ; such too is its extreme manageableness.

Having become satisfied of its power of exciting inflammation in any tissue, I conceived that, by the introduction of needles, for the purpose of conducting the galvanic fluid upon a given point, I might excite inflammation in that point.

The experiments to which I have resorted have amply confirmed the justice of my anticipation.

FIRST EXPERIMENT.

The femoral artery of a dog was laid bare, immediately below Poupart's ligament, and two needles were placed in it; to one of these needles

was attached the copper, to the other the zinc pole of a galvanic battery, which consisted of sixteen pairs of two-inch plates; the contact was renewed three several times at intervals of five minutes.

In four hours and a half after the conclusion of the operation, the dog was destroyed, and, upon examination after death, I found a small coagulum formed around the needles. This coagulum, which was not sufficiently large to be firmly applied to the internal parietes of the artery, was slightly adherent to the sides.

Upon the internal tunic was found a stratum of coagulable lymph; and, when this was removed, the arterial parietes presented a considerable redness.

SECOND EXPERIMENT.

The femoral artery was laid bare, in the same situation as in the last experiment, and perforated by two needles; the galvanic fluid was applied to

these in the same manner as in the last experiment ; in twenty hours afterwards, the dog was destroyed, and, in four hours after death, the artery was examined, when it was found that a coagulum existed, of an inch in length, of considerable consistency, strongly adherent to the arterial parietes, by means of a thick stratum of lymph ; the internal tunic presented a vivid redness of an arborescent character ; the external was much inflamed.

These are the only experiments which I have yet made on the effect of galvanism upon the arteries and the circulating fluids.

I cannot conceal from myself the conviction, that, wherever we find an aneurismal sac, we may with impunity introduce into it attenuated needles, for the purpose of conducting a stream of galvanism, and thereby produce the coagulation of its fluid contents. There is scarcely a part of the animal body which may not be perforated with the most perfect impunity by a very fine needle.

The heart of a dog has been punctured with-

out any inconvenience, and the viscera without any accident. Cloquet has placed needles in the tissue of the lungs, the liver, the testicle, and the intestines. Bretonneau has perforated the cerebrum and the cerebellum of young dogs, without their appearing to suffer the slightest pain. The Japanese employ acupuncture in almost all diseases (in much the same manner as the lower classes in our country employ bleeding), in inflammation of the intestinal tube, in incipient cataract, ophthalmia, &c.

If further experience shall confirm the correctness of these observations, I can scarcely conceive the existence of any case of aneurism which may not be successfully treated by the methods which I have now made known.

I did not resort to any experiments for the purpose of determining the action of galvanic electricity upon the blood. I conceived that experiments made upon blood, out of the system, must necessarily be inconclusive; I therefore

thought it more prudent to resort to actual experiment upon the arteries and the blood, in their natural state in the living body; which would certainly be open to no such objection.

I was aware, it is true, that we had no more delicate test of the existence of albumen than galvanic electricity, and that the immediate effect of the application of this agent to any solution containing the smallest quantity of albumen is to produce its immediate coagulation.

I thought it, therefore, possible that its action upon the circulating blood, containing, as it does, a considerable quantity of albumen, might be similar: the result has confirmed the truth of the opinion; for, in both experiments, coagula were formed around the needles.

I may be allowed to hope, that, in a subject of such immense importance to the human race as that which is the subject of this Essay, no opportunity will be lost in resorting early to experiment for the purpose of testing whether or not the suc-

cess of this mode of operation will be equally brilliant when applied upon the human subject ; and, also, that the result of any operation which may be performed will be immediately given to the world.

The extreme simplicity of the operation, the total absence of danger in its application, place it entirely within the power of every practitioner.

If any apprehension should be at any time felt as to the difficulty of introducing a needle into an artery, I am justified in suggesting, that its result would be not less happy, if the needles were introduced into the aneurismal sac.

In this the most timid or inexpert operator could feel no apprehension ; and I cannot, for a moment, feel any doubt of its entire success.

THE END.